Reflections on bio-membranes

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Model biomembrane systems at the solid-liquid interface are described, including lipid-surfactant mixtures and lipid-lipid mixtures. Although supported lipid bilayers have been used as model membranes for decades, their properties are still relatively poorly characterized compared to other branches of soft-matter such as surfactants and polyelectrolytes. Neutron reflection shows that adsorption of lipid mixtures follows similar principles to surfactant adsorption, and that the surface bilayer has a composition determined by the relative surface affinities of the components. More remarkably, asymmetric membranes can be formed spontaneously, which implies that equilibrium is established between the surface and the lipid bulk solution, and that the lipids are also able to redistribute between the supported bilayer leaflets. Detailed understanding of the properties of model membranes is essential for the interpretation of lipid-protein interactions, which are often studied in model systems for simplicity. In phospholipase A_2 enzyme hydrolysis of lipid membranes, membrane lipids are broke down into lysolipids (detergent-like) and fatty acids. The kinetics of this type of interfacial reaction cannot be analysed without knowledge of the surface-solution partitioning of the enzyme, substrate and reaction products. Neutron reflection and ellipsometry results from model phospholipid bilayers suggest that PLA_2 activity is regulated by fatty acid accumulation and involves partial penetration of the enzyme into the membrane. All major features of the reaction can be predicted using a simple activation energy dependent model which is analogous to the so-called “volcano effect” in heterogeneous (metal) catalysis. In this case, neutron reflection provided the membrane compositional and structural data to support kinetic modeling by measuring the partitioning of the reaction products directly for the first time. The possibilities of using neutron techniques to solve questions related to more complex model membranes are discussed in terms of some topical problems in membrane biophysics, including lipid domains and membrane protein complexation.